REMARKS

Review and reconsideration on the merits are requested.

The prior art considered: Nolte et al (Nolte); Helmer-Metzmann (Helmer-Metzmann).

Allowable subject matter: claims 4, 8 and 12 as being dependent upon a rejected base claim the Examiner stating:

> "Claims 4, 8, 12 would be allowable because the prior art does not disclose or suggest the polymer comprising 30-95 mol% of a first aromatic monomer unit represented by the formula (1) and 70-5 mol% of a second aromatic monomer unit represented by the chemical formula (2) as stated in the claim."

Applicants rewrite claims 4, 8 and 12 in independent form including, it is believed, all of the limitations of the base claim and any intervening claims. Thus, these claims should be allowable.

However, this would leave outstanding the rejection of claims 1, 5 and 9.

Claims 1, 2, 5, 6, 9 and 10 were rejected under 35 U.S.C. § 102(b) as anticipated by Nolte. Paragraph 3 of the Action.

Claims 1, 2, 5, 6, 9 and 10 were rejected under 35 U.S.C. § 102(e) as anticipated by Helmer-Metzmann. Paragraph 4 of the Action.

Claims 3, 7 and 11 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Nolte and as being unpatentable over Helmer-Metzmann. Paragraphs 5 and 6 of the Action.

While technically these rejections would be mooted since these claims are canceled, Applicants do include claims 2/3 into claim 1, include claims 6/7 into claim 5 and include claims 10/11 into claim 9, whereby the rejection of claims 1, 5 and 9 should be an obviousness rejection. Claims 2, 3, 6, 7, 10 and 11 are cancelled.

Turning first to claim 1, as the Examiner will see claim 1 defines the ion-conducting aromatic polymer membrane as having a maximum water absorption in a range of 80-30 weight% based on its dry weight before the hot-water treatment, and the polymer electrolyte membrane which is made of sulfonated polyarylene is subjected to a hot-water treatment comprising immersing the membrane in hot water at 80-95°C or 0.5-5 hours (emphasis added). The above limit regarding the hot water treatment and temperature/time is common to claims 1, 5 and 9.

The Importance of the Initial Water Content of the Sulfonated Polyarylene Membrane

The initial water content of the sulfonated polyarylene membrane should be 80-300 weight%. When the initial water content of the sulfonated polyarylene membrane is less than 80 weight% based on its dry weight, sufficient ion conductivity cannot be obtained even with the hot-water treatment. When the initial water content exceeds 300 weight% based on its dry weight, the sulfonated polyarylene membrane has a high rate of expansion and shrinkage by heat, whereby poor durability will be shown.

Thus, it can be seen that the initial water content limit of 80-300 weight% is an important limitation in the claims herein, especially considering the membrane environment (the Examiner is requested to note that claims 1, 5 and 9 all call for a polymer electrolyte membrane).

The Examiner states in Paragraph 3, lines 5-10, of the Action:

> "The sulfonated poly(arylene ether sulfones) is also treated in hot water (ca. 80°C). See Abstract, pages 211-213. Nolte et al do not specifically disclose the maximum water absorption in a range of 80-300 weight% based on its dry weight before the hot water treatment. However, it is the position of the Examiner that such properties are inherent, given that the materials recited in both Nolte et al and the present application having similar chemistry and chemical structure."

It is respectfully submitted that the Examiner has expanded the sparse teaching in Nolte well beyond what one of ordinary skill in the art would attach that teaching, for the reasons now explained.

Nolte merely discloses:

> "For further purification the sulfonated PSU (poly(arylene ether sulfones)) was extracted in the Soxhlet system with hot water (ca. 80°C)." (see page 213, left column, lines 17-19 of J. of Membrane Sci., 83 (1993) (Nolte).

As discussed in the RESPONSE of February 17, 2004, the hot water "treatment" of Nolte which the Examiner has referred to is simply a process for purifying what might be considered a "raw" sulfonated poly(arylene ether sulfone) (which is not in membrane form) in a Sohxlet system with hot water at a temperature of about 80°C. The purpose of the "hot water treatment" of Nolte is to extract water soluble moieties such as low molecular weight sulfonated poly(arylene ether sulfones), polymer segments of poly(arylene ether sulfones), etc., formed in the poly(arylene ether sulfones). Basically, sulfonated PSU or sulfonated PES prepared by following Scheme 1 or Scheme 2 given at page 215 of Nolte, which would seem to be a "raw" sulfonated PSU or PES, is contacted with hot water at 80°C for extraction.

Nolte quite clearly does not teach or suggest any meaningful conditions for the Nolte hot water treatment (which is actually an extraction of raw material with hot water) except for stating that:

> "For further purification the sulfonated PSU (poly(arylene ether sulfones)) was extracted in a Soxhlet system with hot water (ca. 80°C)."

There is no membrane involved in Nolte; there is no teaching of the 80-300 weight% water absorption limit of the claims of the present application nor is there any teaching of immersing a membrane for 0.5-5 hours as claimed.

Insofar as obviousness is concerned, there is nothing of record which would suggest or support the Examiner's conclusion of obviousness. For that reason standing alone, it is submitted that the Examiner's obviousness rejection is flawed and should be withdrawn.

What is lacking in Nolte is some suggestion that the simple extraction of Nolte in a Soxhlet system (a raw polymer material) would have any advantageous effect with respect to a sulfonated polyarylene membrane as in the present invention, i.e., in contrast to Nolte, in accordance with the present invention the hot-water treatment is carried out by immersing a membrane in hot water at 80-95°C for 0.5-5 hours.

It is important to analyze and appreciate the purpose of the hot water treatment of the present invention. The purpose is to reduce the dependency of the membrane with respect to ion conductivity on humidity. To achieve this effect, the sulfonated polyarylene membrane is subjected to the claimed hot-water treatment. The conditions of the treatment are important. Specifically, when the temperature of the hot water is lower than 80°C or when the immersing time is less than 0.5 hours, the sulfonated ion-conducting, aromatic polymer membrane cannot be provided with sufficient reduced dependency of ion conductivity on humidity. On the hand, when the temperature of the hot water exceeds 95°C, or when the immersing time exceeds 5 hours, the sulfonated ion-conducting aromatic polymer membrane has reduced mechanical strength. See page 12, lines 6-22 of the specification. It would not appear that either of these

factors would be of any meaningful importance with respect to a Nolte "raw" polymer material, further emphasizing the unobviousness of the present invention over Nolte.

Nolte is, of course, silent regarding the maximum water absorption being in a range of 80-300 weight% based on its dry weight for the hot water treatment. While the Examiner's position is that such properties are "inherent" given that the materials in Nolte and Helmer-Metzmann "have similar chemistry and chemical structure.", even assuming *arguendo* this is the case, simple inherency is not supportive of obviousness (albeit it might be supportive of anticipation), i.e., what is lacking is anything which would lead one of ordinary skill in the art to control the maximum water absorption to be in the range of 80-300 weight%.

The maximum water absorption being in a range of 80-300 weight% based on dry weight before the hot water treatment is an important parameter in the present invention.

In more detail, this is quite important in the present invention that the maximum water absorption should be in the range of 80-300 weight% based on dry weight before hot water treatment. This reasons for this is how much the ion conductivity of the sulfonated polyarylene membrane depends on humidity can be expressed by the initial water content of the sulfonated polyarylene membrane. When the initial water content of the sulfonated polyarylene membrane is less than 80 weight% based on dry weight, sufficient ion conductivity cannot be obtained even with the hot-water treatment of the invention. On the other hand, when the initial water content exceeds 300 weight% based on dry weight, the sulfonated polyarylene membrane will show a high rate if expansion and shrinkage under heat, failing to obtain the desired durability (see page 11, line 18 to page 12, line 4 of the specification).

Applicants now address the nature of the sulfonated poly(arylene ether sulfones). Membranes cast from sulfonated PSU solutions are completely water soluble and impossible to characterize (see Nolte page 214, right column, the last paragraph, the last 8 lines). Since membranes made from sulfonated PES have the swelling problem associated with sulfonated poly(arylene ether sulfones), the membranes are crosslinked during casting (see page 217, right column, the last 2 lines to page 219, left column, line 3 and Table 3 of Nolte).

This would mean that the sulfonated poly(arylene ether sulfones) *per se* of Nolte are not used for an ion conductive membrane due to their poor water resistance properties. Accordingly, Applicants respectfully submit that, contrary to the Examiner's position on Nolte, it is quite clear that the properties of the sulfonated poly(arylene ether sulfones) of Nolte are inherently different from those of the sulfonated polyarylenes of the present invention.

For all of the above reasons, Applciants respectfully submit that claim 1 of the present application, as now amended, would certainly not be anticipated by nor rendered obvious by Nolte.

Turning to claims 5 and 9, these both include the essential polymer electrolyte membrane of claim 1, and Applicants respectfully submit that the patentability of claims 5 and 9 is established based on the above discussion.

Withdrawal of the rejection of any claims over Nolte is requested.

Applicants now address the rejection of the claims over Helmer-Metzmann.

The Examiner states in Paragraph 4, lines 5-12, of the Action:

> "A chlorosulfonated material is suspended in water and the suspension is boiled (a hot water treatment), so that the polyarylene sulfide-sulfonic acid chloride is converted

> into the polyarylene sulfide-sulfonic acid. See column 1, lines 9-61; column 2, lines 6-25, 64-67. Helmer-Metzmann et al do not specifically disclose the maximum water absorption in a range of 80-300 weight% based on its dry weight before the hot-water treatment. However, it is the position of the Examiner that such properties are inherent, given that the materials recited in both Helmer-Metzmann et al and the present application having similar chemistry and chemical structure."

The Examiner's specific attention is directed to the teaching in Helmer-Metzmann "the suspension is boiled". The phrase "the suspension is boiled" is technically completely distinct and non-analogous to any aspect of the present invention. The phrase "suspension is boiled" means that a suspension of the sulfonated material in water is decomposed to polyarylene-sulfide-sulfonic acid by heating at 100°C. From a mechanism viewpoint, the chlorosulfonated material is hydrolyzed to polyarylene sulfide-sulfonic acid by water. In no fashion does "suspension is boiled" in Helmer-Metzmann suggest to one of ordinary skill in the art or correspond to "a hot-water treatment" by subjecting a sulfonated polyarylene membrane to immersing in hot water at 80-95°C for 0.5 to 5 hours as claimed in the present application (see page 12, lines 8-14 of the specification). Rather, "suspension is boiled" is a hydrolysis of a suspension of chlorosulfonated material in boiling water for a period of 15 hours. See column 3, lines 46-47 of Helmer-Metzmann.

What is lacking from the Examiner's rejection is any suggestion that the hydrolysis of Helmer-Metzmann (100°C, boiling, 15 hours) would, in any fashion, have any beneficial effect on a membrane in the sense of the present invention. Without such teaching, there is no motivation to modify from the extremely different conditions in Helmer-Metzmann with the extremely different purpose to reach the claims of the present invention.

Applicants have specifically noted that Helmer-Metzmann teaches formation of a film of PPS-sulfonic acid (polyarylene sulfide-sulfonic acid) having a thickness of 100 μm by dissolving PPS-sulfonic acid in N-methylpyrrolidone. However, such film is not subjected to any hot water treatment. See column 4, lines 38-43, Example 4 of Helmer-Metzmann.

Further, Helmer-Metzmann is silent regarding maximum water absorption being in a range of 80-300 weight% based on dry weight before hot water treatment as mandated in the claims herein.

Since the ion conductivity of a sulfonated polyarylene membrane is largely dependent on humidity, to obtain stable output at an initial stage of operation and during stationary operation of a sulfonated polyarylene membrane as a polymer electrolyte membrane, such a membrane in such a system should have as low a dependency of ion conductivity on humidity as possible. How much the ion conductivity of the sulfonated polyarylene membrane depends on humidity can be expressed by the initial water content of the sulfonated polyarylene membrane. Thus, in the claimed invention, the maximum water absorption is in a range of 80-300 weight% based on dry weight before the hot water treatment (see page 11, lines 12-26 of the specification).

Accordingly, one of ordinary skill in the art referring to Helmer-Metzmann, which fails to teach or suggest:

Any hot water treatment comprising immersing a membrane in hot water at 80-95°C for 0.5-5 hours;

any relevance of the maximum water absorption, and certainly not a maximum water-absorption in the range of 80-300 weight% based on dry weight before hot water treatment;

would not be motivated in any fashion to find the claims of the present application obvious.

Although Applicants have argued claim 1, their position on claims 5 and 9 is essentially the same as with respect to claim 1.

Withdrawal of all rejections based on Helmer-Metzmann is requested.

Respectfully submitted,

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